Jared Wheeler

CAD Comparison and Export of 4D InSpec Surface Data

Can 3D measurements be plotted against CAD drawings?

Introduction

There are times when the computed surface parameters of a part is not enough, and a comparison of the data to a CAD model is desirable. With complex shapes, it may not be possible to remove the surface shape for assessment of details, and so the only way to readily quantify defects is by comparing it to the original CAD model. Another case would be if a user wishes to convert 4D InSpec data to a CAD format for use in lifetime models or other advanced analysis.

This Application Note uses a VRMesh Reverse software package[1] trial version to illustrate the process one can use to compare a 4D InSpec gauge's surface measurement against the original CAD model and to export results to various CAD-compatible formats. The results were obtained quickly, and in an easy to understand format.

Example

To illustrate the process, 4D Technology designed and then 3D-printed a small, complex sample that could be measured using the 4D InSpec XL product (Figure 1). Even using coarse ruler measurements, the 3D-printed material showed lower peaks than the drawing. The 3D printing process produced uneven surfaces and rounded corners. Our objective was to export a 4D InSpec measurement of the printed part, import it into a CAD modeling program, and quantify differences. While our part deviated from the design drawing through infidelity of the printing process, variations in a part from the model could just as well have been caused by nicks, dents, scratches or other defects or damage. Details of the part measurement for this note are shown in Figure 2.

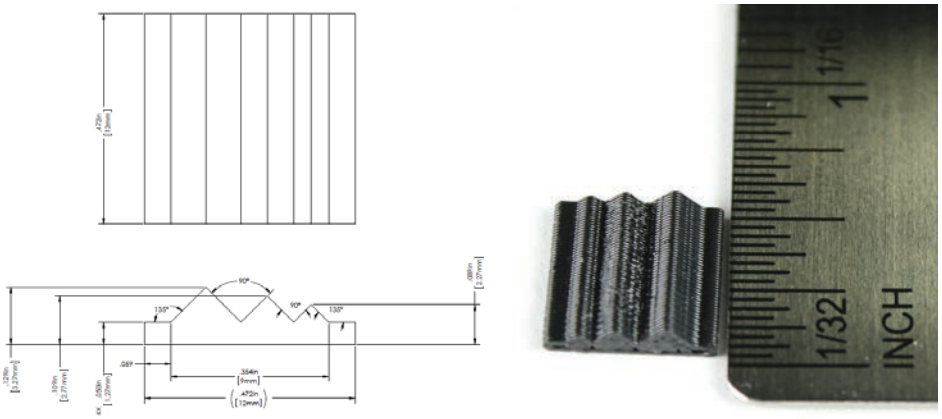


Figure 1: Test piece dimensions (left) and actual 3D printed test piece (right)

Take a measurement

For the sake of brevity, we'll not describe the process of taking a measurement. The instrument takes a handheld, non-contact 3D measurement. It captures data about as easily as taking a picture with a cell phone. For an understanding of

how measurements are taken with 4D InSpec XL, how to mask a viewing area, or measurement analysis, take a look at our online training videos.

Here's the measurement screen from the 3D-printed part:

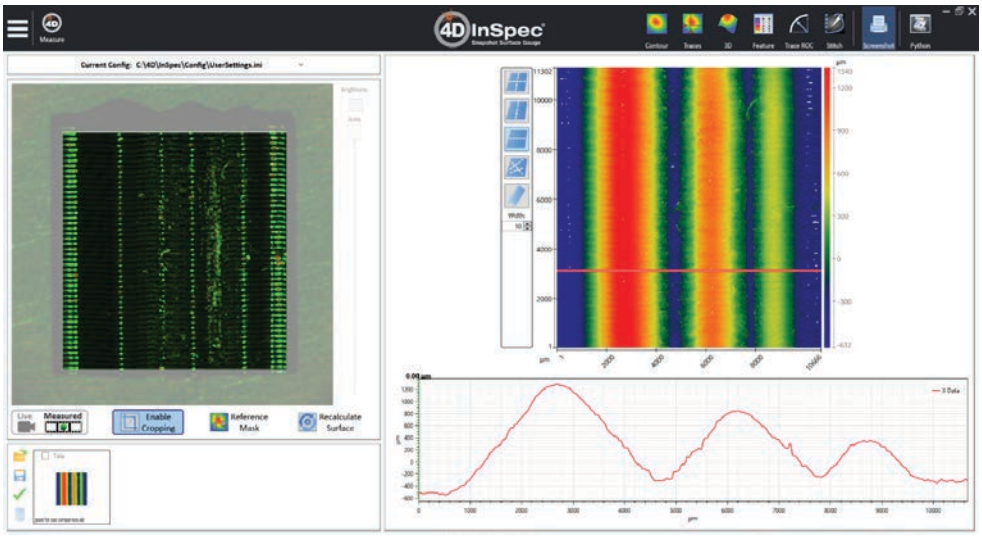


Figure 2: 3D Measurement (plotted, upper right) of sample part (green camera image on the left) using 4D InSpec XL. A 2D trace was drawn across one slice (red line, bottom right).

Saving Point Cloud Data (.xyz files) from the 4D InSpec Software

- Highlight the measurement to be saved in the measurement history bar at the bottom left of the software screen.
- Click the Save icon.
- Select .xyz from the pull-down options for File Type instead of the default binary .4D format. Note: the 4D software cannot load .xyz files as they do not contain the full measurement information but only the surface point cloud. For future re-analysis, save as a .4d file too.
- Enter the filename and select Save.
- Note the .xyz file only uses microns as its dimensions. The VRMesh software can numerically scale the data (for example from millimeters to microns or vice versa).

Using VRMesh

Opening the .xyz Point Cloud Data in VRMesh and Creating a Mesh

1. Open the VRMesh software and select import (File → import).
2. Select the file type as .xyz and then select/open the previous saved file from the 4D software.
3. When prompted with format options, select the second one that says: (Delimiter by Others- , ;). Push "Okay".
4. When prompted to create an index file and attach it, select "Yes". Push "Okay" again if there is another prompt informing you where the index file will be saved. This will then take a few seconds.
5. Turn your point cloud into a mesh file. Select the tab "Point Cloud" and then push "Point Cloud to Mesh Wizard" as indicated in Figure 3.

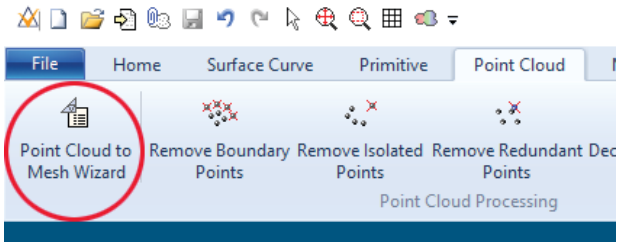


Figure 3.

6. When prompted with the Figure 4 options, the defaults will likely work fine. If your mesh does not come out as expected, go back through this process and follow VRMesh's recommendations. For this test piece, only minor changes were necessary.

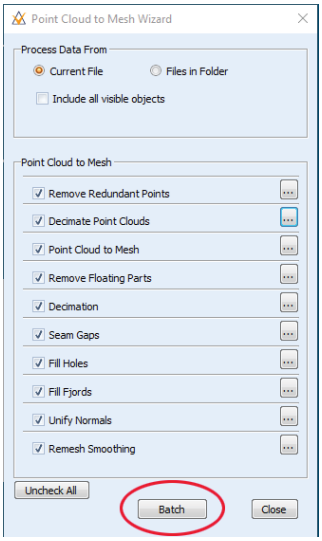


Figure 4.

7. Push "Batch" to create the final mesh. Note it is possible to repair the mesh afterwards. This is done in the tab called "Mesh Repair".
8. The software will display a screen similar to the one in Figure 5, showing a mesh in the middle of the screen, and one item in the object tree to the right. The view options and object positioning are similar to other CAD programs.

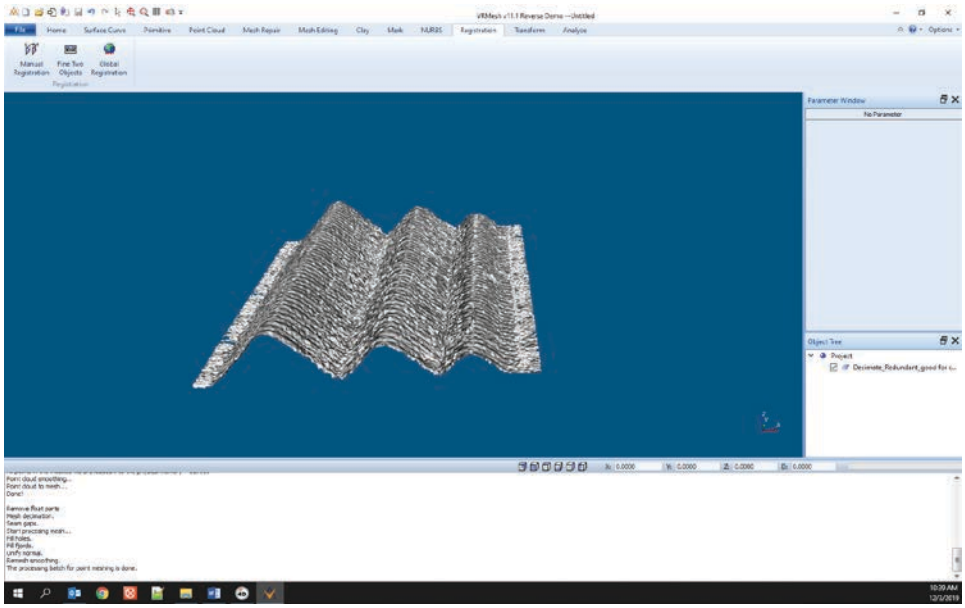


Figure 5.The mesh, after converting the point cloud to mesh.

9. The mesh may be saved in a variety of formats for import into other software packages for additional analysis. VRMesh supports saving the mesh in the following formats: stl, obj, dxf, fbx, shp, grid, wrl, ply, vtk, x3d, ifc
10. Import the CAD file for comparison. Use the same procedure as steps 1 and 2 but select your file type (this example used a .step file).
11. If the units between the mesh and CAD file don't match, use the Numerical Scaling feature to convert units via the following steps:
    a. Select the file to scale in the object tree.
    b. Push "Numerical Scale." This is in the transform tab as shown below.
    c. Parameters will pop-up on the right in the Parameter Window. Make sure under the Factor of Scale section that Uniform is checked.
    d. Enter the scale factor into any of the coordinate boxes.
    e. Scroll down in the Parameter Window and push apply.
    f. This example scaled the CAD file (created in mm) by 1000 to match the micron units of the mesh.

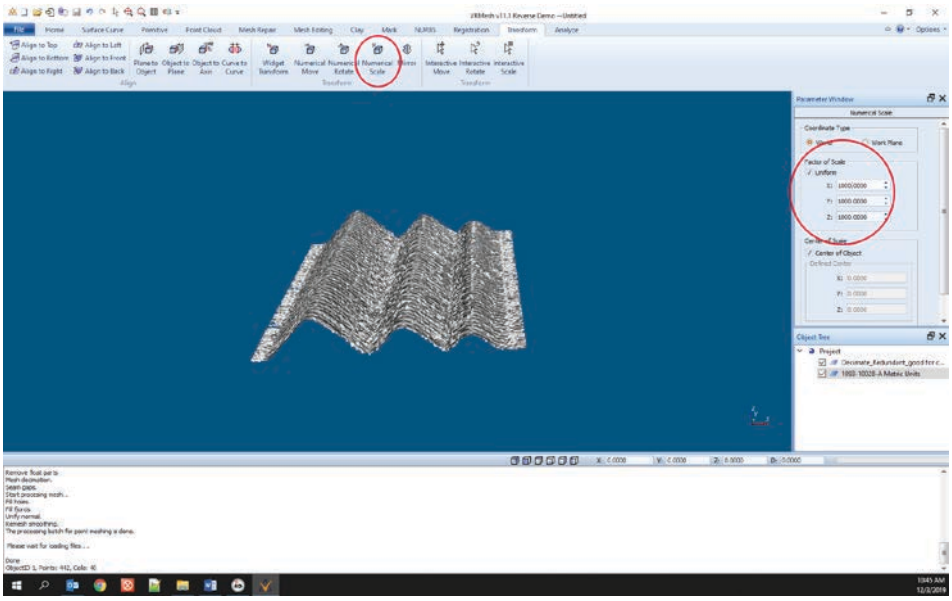


Figure 6. Check scaling.

Alignment

1. After scaling (if necessary), two objects will be displayed. Use the Interactive Move Command (in the Transform tab) to separate them if they are not already separated. Simply select the object that needs to move, push the “Interactive Move” button, and then click and drag it to the desired location.
2. Once separated, Select the Registration tab and push “Manual Registration” (Figure 7).

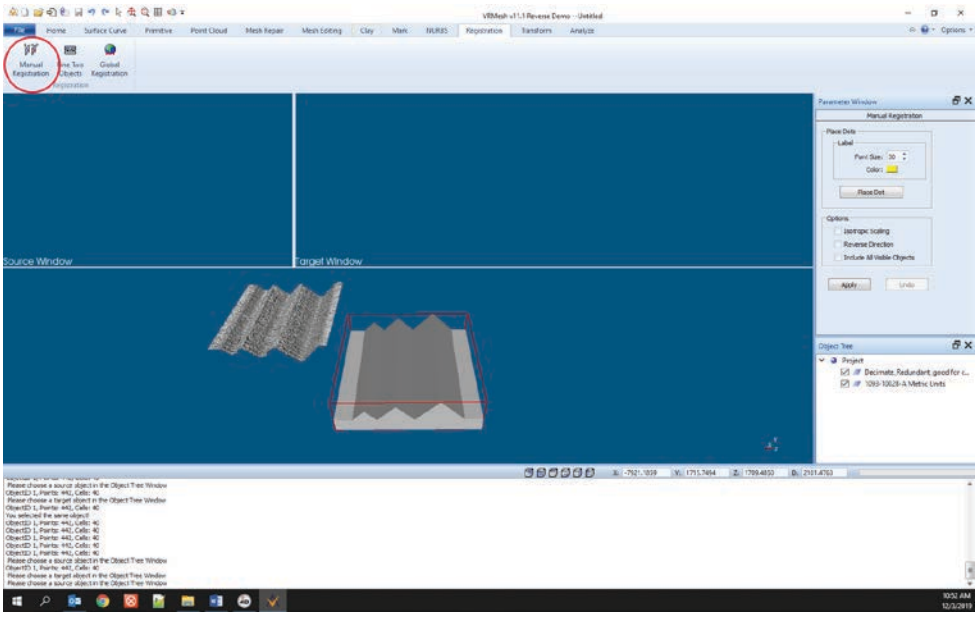


Figure 7. Locating “Manual Registration”

3. Click the “Source Window” and then click your CAD Model. The CAD model will appear in the source window.
4. Next click the Target Window and click your Mesh. The Mesh will appear in the Target Window.
5. By clicking the scroll button on your mouse or other CAD positioning tools, rotate, size, and orientate each object to best match the Source and Target Windows as

shown:

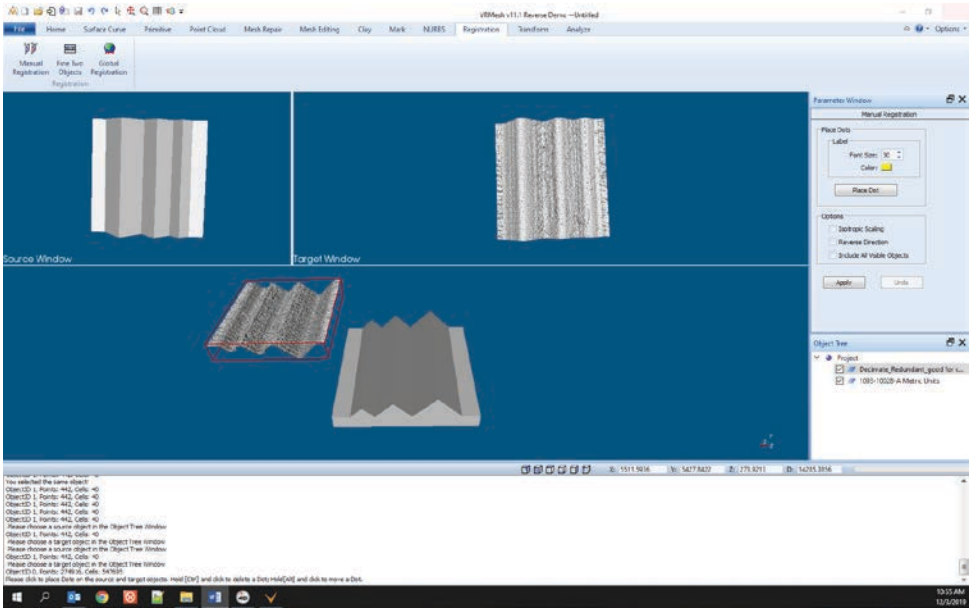


Figure 8. Initial placement of source and target in the alignment process.

6. Select 4 distinctive points on the source window first. Then select 4 points on the target window as shown below. (VRMesh made an excellent video of this process that is on their website or located here: https://www.youtube.com/watch?v=PRZbLdl_Uxs&feature=youtu.be.) Note: this step is only intended as a rough alignment. It will be optimized in the next steps.

Figure 9. Detail of selection points.

7. Push “Apply” in the Parameter Window.
8. The objects will align in the bottom window. If they look aligned, right click the bottom window and select: “Extend to selected object”.
9. Now you can more finely tune the alignment and there are multiple ways to do this (see VRMesh videos for additional examples). Using a manual method:
   a. Select the CAD model in the object tree
   b. Select the Home Tab and push the “Wireframe” button. You will now see the mesh within the CAD model, which makes it easier to see how well it aligned.

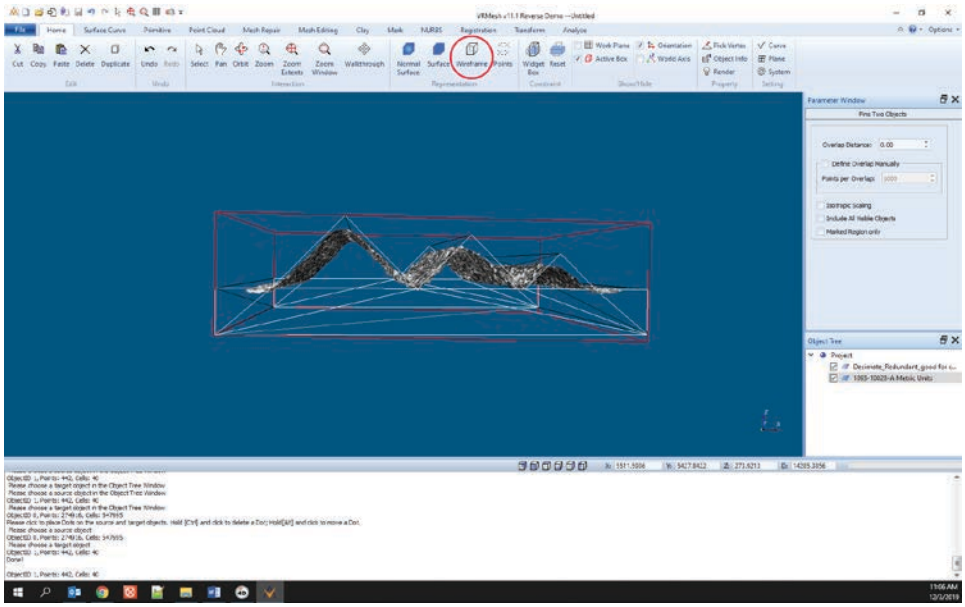


Figure 10. Turning on the wireframe display of the CAD model.

c. It may be hard to tell from a screenshot, but the mesh file aligned slightly below the CAD frame's top surface.
The 3D printed material has a waviness to it and the software aligned the top of the wave compared to the bottom of the CAD file flat areas. The mesh needs to be slightly moved up in the Z-axis to match the middle of the waviness (*i.e.* the average of the surface) to the flat sections of the CAD model.

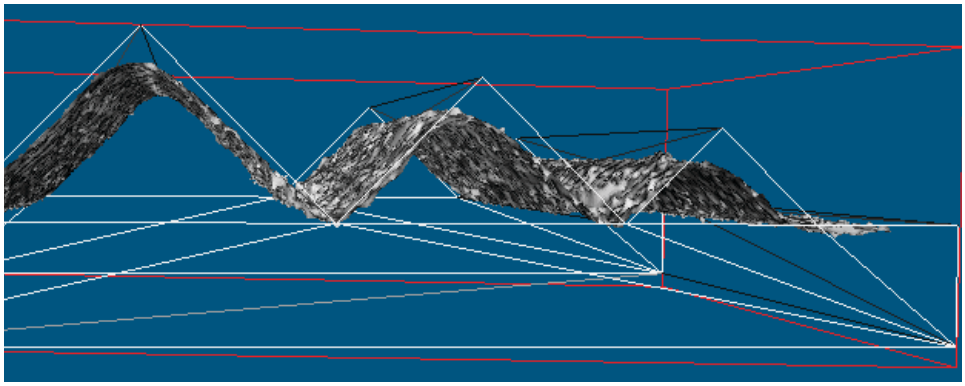


Figure 11. Detail showing the measurement sitting generally below the wire frame.

d. Select the Mesh File

e. Select the Transform Tab and push the "Numerical Move" button. As shown below, you will see options on the right in the parameter window.

f. Select relative coordinate in Coordinate Type.

g. Use the appropriate XYZ coordinate and select a reasonable value for your units. For microns, this example used increments of 10 in the Z-Axis. Keep applying the increment until visually it looks aligned.

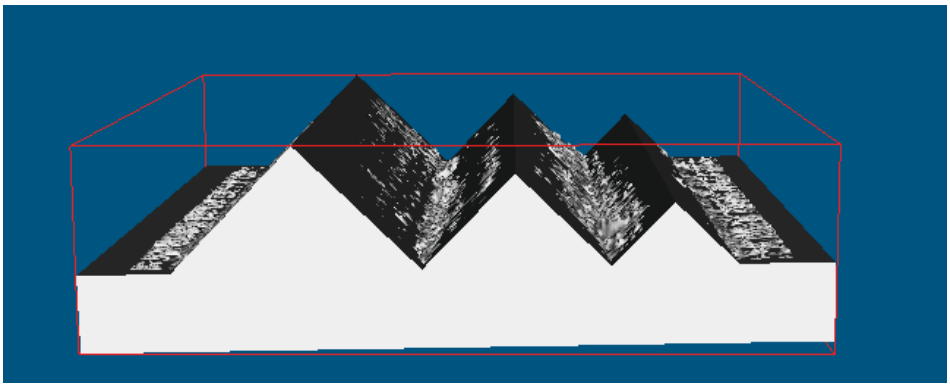


Figure 12. After fine alignment.

After-Alignment Inspection

We are now ready to compare—*i.e.*, inspect—the differences. We chose one of the easiest ways to inspect in the VRMesh software. Analysis only took a few seconds.

1. Select the Analyze tab and push “Inspection” (the first button in the tab).
2. Select the CAD object and then the Mesh Object.
3. You will likely want to put one of the objects in wireframe viewing. We set the CAD model in wireframe.
4. The result shows, by color, the height differences (positive and negative) between the surfaces.
5. For our test, the default scale was too broad—it defaulted to the peak and valley of the plots shape, not local variations of the surfaces. We adjusted the “Minimum” and “Maximum” values in the Parameter Window down to a value range that represented height deviations on the surface.

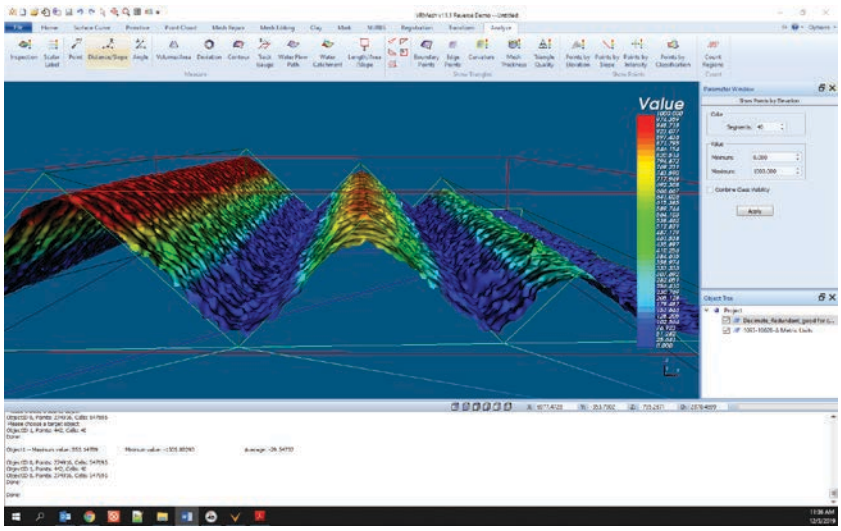


Figure 13. The default color settings spanned the full heights of the object’s shape, losing the details of variation in the surface.

6. To preserve your results, take a screenshot, export the numerical values to a text file, or save the file.

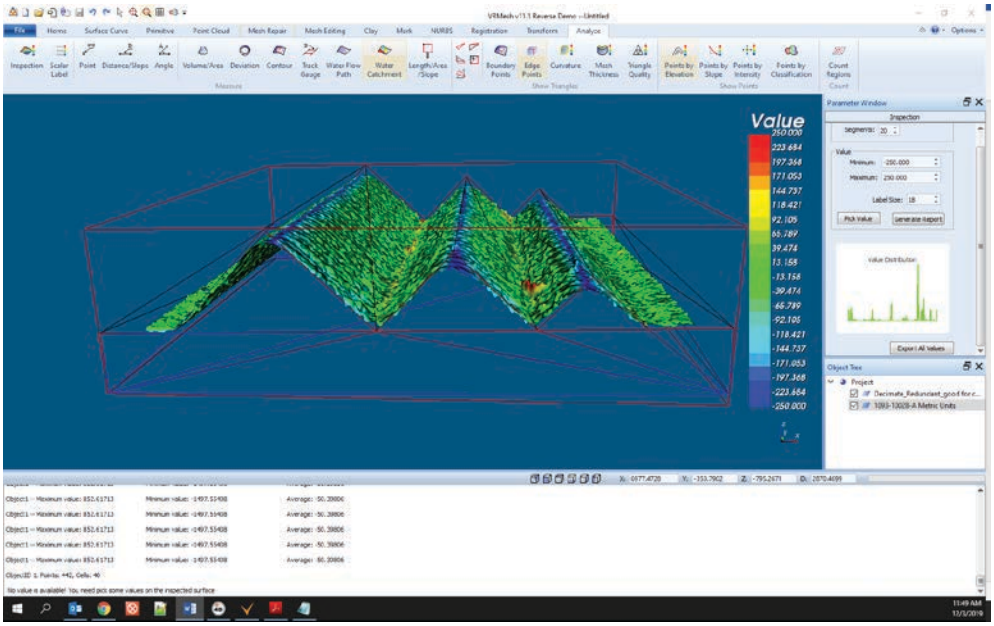


Figure 14. After adjusting height scale, differences in the model verses the part jump out as high spots (red) and low spots, (blue).

Conclusions

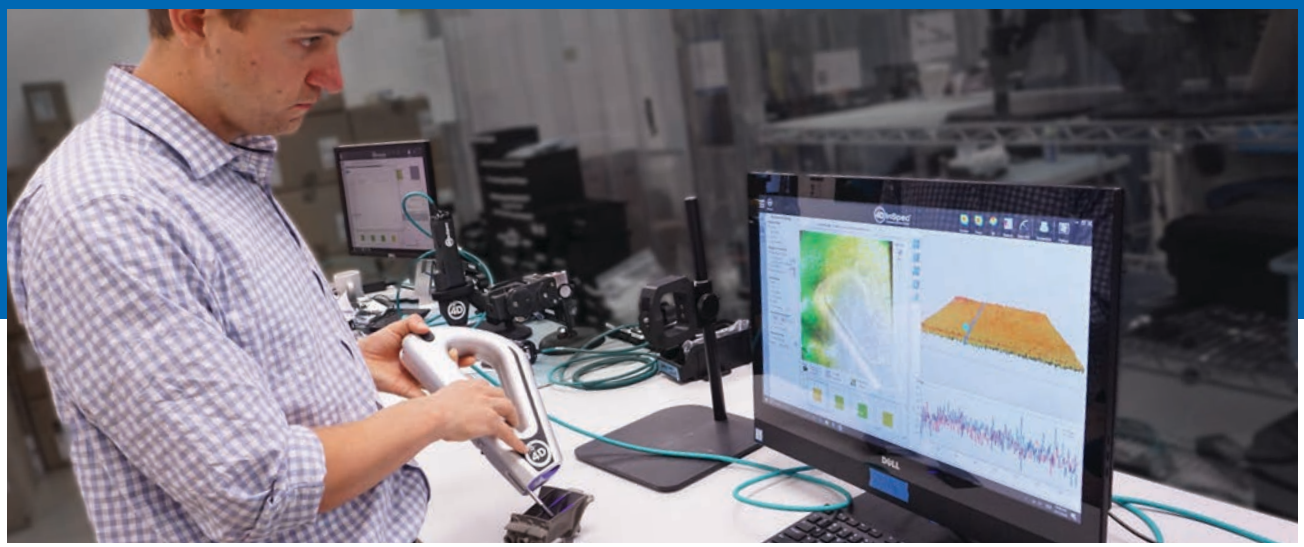
From the inspection data, it appears the part's peaks are roughly 200 microns lower than the model. Also, there are some high areas in the troughs, of nearly 100 µm deviation from the model.

Thus, this method provides a comprehensive way of quantifying the entirety of the true surface, with respect to its ideal shape.

Endnotes

1 4D Technology does not endorse VRMesh nor have any relationship with the company. The software is used herein merely as one example of software designed to accomplish these tasks. A 30 day trial version is available on their website. 2019.12.17 https://www.vrmesh.com

Measure well, and get better parts yield



Hand-held 4D InSpec XL provides 3d surface defect measurements in seconds, complete with pass-fail analysis of the large 15 mm field of view. Rugged enough to use on the shop floor, yet precise and repeatable results make it a breakthrough for machined/additive parts manufacturing, QA and MRO.

Need to measure?

Click here for the
4D InSpec surface inspection gauge
Data Sheets

Get 3D surface measurements of parts defects in a portable, handheld instrument. Fast and accurate, you can increase your yield while reducing turnaround time.

See for yourself. We'll do a demonstration.

4D is the first name in dynamic metrology.

info@4DTechnology.com
(520) 294-5600
www.4DTechnology.com

4D Technology
An Onto Innovation Business